AMENDMENT

(amendment under the provision of Article 11)

TO: The Commissioner of Patent Office Esq.

1. Indication of International Application: PCT/JP03/10419

2. Applicant
   name: NEC Corporation
   address: 7-1, Shiba 5-chome, Minato-ku, Tokyo 108-8001, Japan
   nationality: JAPAN
   residence: JAPAN

3. Attorney
   name: Patent Attorney (6401): HAMADA Haruo
   address: Wisdom House, 4-12, Minami-Aoyama 3-chome,
   Minato-ku, Tokyo 107-0062 JAPAN

4. Object of the Amendment
   specification and claims

5. Contents of the Amendment
(1) Amend the paragraph in lines 22~25 at page 3
"The present invention provides a cooling apparatus for cooling a heat generator in electronic devices comprising a liquid cooling unit discharging heat generated by the heat generator with coolant, and an air cooling unit

having a cooling fin group for exhausting heat discharged by the liquid cooling unit in atmosphere, wherein the air cooling unit is stacked onto the liquid cooling unit."

to

"The present invention provides a cooling apparatus for cooling a heat generator in electronic devices comprising a first flow path, in which a coolant flows, embedded in a base, a liquid cooling pump disposed on a surface of the base for circulating the coolant, a liquid cooling unit having a second flow path embedded in the base for connecting the first flow path and the liquid cooling pump, and an air cooling unit member disposed on the base. ".

(2) Amend the paragraph in lines 1~3 at page 4

"The liquid cooling unit may comprise a heat absorption surface absorbing heat by one of method of contacting and joining with the heat generator, a flow path, in which the coolant flows, formed along the heat absorption surface, and a liquid cooling pump for circulating the coolant within the flow path."

to

"The present invention also provides a cooling apparatus for cooling a heat generator in electronic devices comprising an unit for liquid cooling having a flow path in which a coolant flows and a liquid cooling pump for circulating the coolant, both of which are embedded in a base, and an air cooling unit member disposed on the base. ".

(3) Amend claim 1 at page 29

"1 A cooling apparatus for cooling a heat generator in electronic devices comprises:

a liquid cooling unit discharging heat generated by the heat generator with a coolant; and

an air cooling unit having a cooling fin group for exhausting heat discharged by the liquid cooling unit in atmosphere,

wherein the air cooling unit is stacked onto the liquid cooling unit."

to

"1 (Amended) A cooling apparatus for cooling a heat generator in electronic devices comprises:

a first flow path, in which a coolant flows, embedded in a base;

a liquid cooling pump disposed on a surface of the base for circulating the coolant;

a liquid cooling unit having a second flow path embedded in the base for connecting the first flow path and the liquid cooling pump; and

an air cooling unit member disposed on the base.".

(4) Amend claim 2 at page 29

"2 A cooling apparatus according to claim 1, wherein the liquid cooling unit comprises:

a heat absorption surface absorbing heat by one of method of contacting and joining with the heat generator;

a flow path, in which the coolant flows, formed along the heat absorption surface; and

a liquid cooling pump for circulating the coolant within the flow path."

to

"2 (Amended) A cooling apparatus for cooling a heat generator in electronic devices comprises:

an unit for liquid cooling having a flow path in which a coolant flows and a liquid cooling pump for circulating the coolant, both of which are embedded in a base; and

an air cooling unit member disposed on the base.".

(5) Amend claim 3 at page 29

"3 A cooling apparatus according to claim 2, wherein the flow path is formed by joining a base having a groove and the heat absorption surface. "

to

"3 (Amended) A cooling apparatus according to one of claims 1 and 2, wherein the flow path is formed by joining a base having a groove and the heat absorption surface. "

(6) Amend claim 4 at page 29

"4 A cooling apparatus according to claim 3, wherein the air cooling fin group and the base are formed in a unit."

to

"4 (Amended) A cooling apparatus according to one of claims 1 and 2, wherein an air cooling unit is disposed an air cooling fin group for exhausting heat, which is diffused by the liquid cooling unit, in atmosphere.".

(7) Amend claim 5 at page 29

"5 A cooling apparatus according to claim 2, wherein the flow path is formed within at least one of fin among a plurality of fins composing the air cooling group."

to

"5 (Amended) A cooling apparatus according to claim 4, wherein the flow path is formed within at least one of fin among a plurality of fins composing the air cooling group.".

(8) Amend claim 6 at page 29
"6 A cooling apparatus according to claim 1, wherein the air cooling unit comprises an air cooling fan for flowing air to the air cooling fin group."
to
"6 (Amended) A cooling apparatus according to claim 2, wherein the air cooling unit comprises an air cooling fan for flowing air to the air cooling fin group.".

(9) Amend claim 8 at page 30
"8 A cooling apparatus according to claim 1, wherein at least one air hole for supplying air to the air cooling unit is formed in the liquid cooling unit."
to
"8 (Amended) A cooling apparatus according to one of claims 1 and 2, wherein at least one air hole for supplying air to the air cooling unit is formed in the liquid cooling unit.".

(10) Amend claim 9 at page 30
"9 A cooling apparatus according to claim 1, wherein the air cooling fin group is divided into a plurality of groups, and an air hole supplying air to the air cooling fin group is formed in each plurality of groups of the air cooling fin group in the liquid cooling unit."
to

"9 (Amended) A cooling apparatus according to one of claims 1 and 2, wherein the air cooling fin group is divided into a plurality of groups, and an air hole supplying air to the air cooling fin group is formed in each plurality of groups of the air cooling fin group in the liquid cooling unit.".

(11) Amend claim 15 at page 31

"15 A cooling apparatus according to claim 1, wherein the air cooling unit comprises:

a piezoelectric material supported by a support member; and

an air blow plate, which is bonded to the piezoelectric material, generating air flow through vibration thereof by controlling voltage of the piezoelectric materials."

to

"15 (Amended) A cooling apparatus according to one of claims 1 and 2, wherein the air cooling unit comprises:

a piezoelectric material supported by a support member; and

an air blow plate, which is bonded to the piezoelectric material, generating air flow through vibration thereof by controlling voltage of the piezoelectric materials.".

(12) Amend claim 20 at pages 31~32

"20 A cooling apparatus according to claim 2, wherein the flow path is a closed loop with a circulation method, and in a part of the closed loop, a micro channel structure having a smaller cross section area than a cross section area of the flow path is formed."

to

"20 (Amended) A cooling apparatus according to one of claims 1 and 2, wherein the flow path is a closed loop with a circulation method, and in a part of the closed loop, a micro channel structure having a smaller cross section area than a cross section area of the flow path is formed.".

(13) Add claim 34

"34 (Added) A cooling apparatus according to claim 3, wherein the air cooling fin group and the base are formed in a unit."

6. List of the Attachments

a copy of pages 3~ 4 of the specification

a copy of pages 29~ 33 for claims

a copy of pages 3~4 of the specification

However, the conventional cooling apparatus comprises the heat-sink 101, the enforced cooling unit 104 as a heat-discharge unit, and a heat-discharge pipe 102 connecting the both. In addition, the apparatus further comprises, for example, a pump cover and a heat-sink cover. Then, assembly and fixing of the apparatus to an electronic device body are complex. Furthermore, since a setting position of the air cooling unit having a fan is limited to the vicinity of the enforced cooling unit 104 in which the liquid circulation pump 106 is set, the cooling performance has been not sufficient.

In addition, since a conventional cooling apparatus is equipped with the liquid circulation pump 106 for the enforced air cooling, a pump unit has become large and complex compared with that of pump itself, thereby the total configuration of the apparatus has been thick.

Furthermore, since the conventional cooling apparatus is built with a resin gasket, the coolant of the apparatus has been lost bit by bit by leaking outside of the apparatus during long use, and thereby the cooling performance has been degraded.

DISCLOSURE OF THE INVENTION

Under the status described in the above, a development of a cooling apparatus for electronic devices, which is free from the above issues, has been expected.

It is therefore an object of the present invention to provide a cooling apparatus for electronic devices which is free from the above issues.

It is another object of the present invention to provide a cooling

apparatus for electronic devices which is easy to build and to fix it to electronic devices, superior in thermal conduction and heat dissipation, and possible to make thin the total configuration of the apparatus.

The present invention provides a cooling apparatus for cooling a heat generator in electronic devices comprising a first flow path, in which a coolant flows, embedded in a base, a liquid cooling pump disposed on a surface of the base for circulating the coolant, a liquid cooling unit having a second flow path embedded in the base for connecting the first flow path and the liquid cooling pump, and an air cooling unit member disposed on the base.

The present invention also provides a cooling apparatus for cooling a heat generator in electronic devices comprising an unit for liquid cooling having a flow path in which a coolant flows and a liquid cooling pump for circulating the coolant, both of which are embedded in a base, and an air cooling unit member disposed on the base.

The flow path may be formed by joining a base having a groove and the heat absorption surface.

The air cooling fin group and the base may be formed in a unit.

The flow path may be formed within at least one of a fin among a plurality of fins composing the air cooling group.

The air cooling unit may comprise an air cooling fan for flowing air to the air cooling fin group

The air cooling unit may comprise a first air channel totally covering the air cooling fin group, wherein an air flow generated by the air cooling fan is controlled by the first air channel.

At least one air hole for supplying air to the air cooling unit may be formed in the liquid cooling unit.

The air cooling fin group may be divided into a plurality of groups, wherein the air hole supplying air to the air cooling fin group is formed for each plurality of groups of the air cooling fin group in the liquid cooling unit.

The air cooling unit may further comprise a second air channel covering each plurality of groups of the air cooling fin group, wherein an air flow generated by the air cooling fan is controlled by the second air channel for not to thermally interfering among the plurality of groups of the air cooling unit.

a copy of pages 29~ 33 for claims

WHAT IS CLAIMED IS:

1 (Amended) A cooling apparatus for cooling a heat generator in electronic devices comprises:

a first flow path, in which a coolant flows, embedded in a base;

a liquid cooling pump disposed on a surface of the base for circulating the coolant;

a liquid cooling unit having a second flow path embedded in the base for connecting the first flow path and the liquid cooling pump; and

an air cooling unit member disposed on the base.

2 (Amended) A cooling apparatus for cooling a heat generator in electronic devices comprises:

an unit for liquid cooling having a flow path in which a coolant flows and a liquid cooling pump for circulating the coolant, both of which are embedded in a base; and

an air cooling unit member disposed on the base.

3 (Amended) A cooling apparatus according to one of claims 1 and 2, wherein the flow path is formed by joining a base having a groove and the heat absorption surface.

4 (Amended) A cooling apparatus according to one of claims 1 and 2, wherein an air cooling unit is disposed an air cooling fin group for exhausting

heat, which is diffused by the liquid cooling unit, in atmosphere.

5 (Amended) A cooling apparatus according to claim 4, wherein the flow path is formed within at least one of fin among a plurality of fins composing the air cooling group.

6 (Amended) A cooling apparatus according to claim 2, wherein the air cooling unit comprises an air cooling fan for flowing air to the air cooling fin group.

7 A cooling apparatus according to claim 6, wherein the air cooling unit comprises a first air channel totally covering the air cooling fin group, and an air flow generated by the air cooling fan is controlled by the first air channel.

8 (Amended) A cooling apparatus according to one of claims 1 and 2, wherein at least one air hole for supplying air to the air cooling unit is formed in the liquid cooling unit.

9 (Amended) A cooling apparatus according to one of claims 1 and 2, wherein the air cooling fin group is divided into a plurality of groups, and an air hole supplying air to the air cooling fin group is formed in each plurality of groups of the air cooling fin group in the liquid cooling unit.

10 A cooling apparatus according to claim 9, wherein the air cooling unit further comprises a second air channel covering each plurality of groups of the air cooling fin group, and an air flow generated by the air cooling fan is

controlled by the second air channel for not to thermally interfering among the plurality of groups of the air cooling unit.

11 A cooling apparatus according to claim 10, wherein the air cooling unit further comprises an air cooling fan in each second air channel.

12 A cooling apparatus according to claim 11, wherein the air cooling unit comprises:

a first air channel totally covering the air cooling fin group;

a second air channel covering each plurality of groups of the air cooling fin group respectively;

a common air flow path formed by the first air channel; and

a plurality of individual air flow paths formed by the plurality of second flow paths.

13 A cooling apparatus according to claim 12, wherein the air cooling unit comprises an air cooling fan arranged in the common air flow path, and an air flow is generated in each individual air flow path by the air cooling fan.

14 A cooling apparatus according to claim 13, wherein a cross section area of an aperture at a border between the individual air flow path and the common air flow path is formed to become larger according the distance from the air cooling fan so that a volume of air flow in the individual air flow path becomes equal.

15 (Amended) A cooling apparatus according to one of claims 1 and 2,

wherein the air cooling unit comprises:

a piezoelectric material supported by a support member; and

an air blow plate, which is bonded to the piezoelectric material, generating air flow through vibration thereof by controlling voltage of the piezoelectric materials.

16 A cooling apparatus according to claim 15, wherein a shape of the air blow plate becomes wider with leaving from the piezoelectric material.

17 A cooling apparatus according to claim 15, wherein the air blow plate comprises:

a first part having a first elastic constant located at closer side to the piezoelectric material; and

a second part having a second elastic constant, which is higher than the first elastic constant, located at more distant side from the piezoelectric material.

18 A cooling apparatus according to claim 15, wherein the air blow plate comprises:

a first part having a first thickness located at closer side to the piezoelectric material; and

a second part having a second thickness, which is thicker than the first thickness, located at more distant side from the piezoelectric material.

19 A cooling apparatus according to claim 15, wherein the air cooling unit comprises an arrangement of a plurality of piezoelectric fans along an air flow,

and the each piezoelectric fan adjacently arranged to each other is driven by shifting a vibration phase of the air blow plate of piezoelectric fan by 1/2 cycle or 1/4.

20 (Amended) A cooling apparatus according to one of claims 1 and 2, wherein the flow path is a closed loop with a circulation method, and in a part of the closed loop, a micro channel structure having a smaller cross section area than a cross section area of the flow path is formed.

21 A cooling apparatus according to claim 20, wherein the micro channel structure is formed by joining a base arranging a plurality of narrow grooves and the heat absorption surface.

22 A cooling apparatus according to claim 1, wherein the liquid cooling unit comprises a piezoelectric pump having a platy piezoelectric element as a driving source, and the coolant is circulated by the piezoelectric pump.

23 A cooling apparatus according to claim 22, wherein the piezoelectric pump comprises a stacking plate structure having a check valve of plate vane structure for controlling a flow direction of the coolant.

24 A cooling apparatus according to claim 22, wherein the piezoelectric pump is built into the liquid cooling unit, and the piezoelectric pump and the liquid cooling unit are integrated in a unit with metal material.

25 A cooling apparatus according to claim 22, wherein the piezoelectric

pump comprises:

a plurality of pump members for introducing and exhausting the coolant; and

a plurality of piezoelectric pump driving members for driving the plurality of pump members.

26 A cooling apparatus according to claim 25, wherein the plurality of piezoelectric pump driving members control timings of introduction and exhaust of the coolant of the plurality of pump members in different timing to each other.

27 A cooling apparatus according to claim 25, wherein the piezoelectric pump driving member conducts an exhaust more than two times longer than an introduction of the pump member.

28 A cooling apparatus according to claim 1, wherein the liquid cooling unit comprises a piezoelectric pump having a toric piezoelectric actuator as a driving source, and the coolant is circulated by the piezoelectric pump.

29 A cooling apparatus according to claim 1, wherein the liquid cooling unit comprises an evaporation-method pump circulating the coolant with evaporation of the coolant by a heat generator.

30 A cooling apparatus according to claim 29, wherein the evaporation-method pump comprises a plurality of heat generators, and a flow direction of the coolant is determined by controlling heat generation timing of the plurality

of heat generators.

31 A cooling apparatus according to claim 1, wherein the apparatus further comprises:

an air cooling fan supplying air to a liquid cooling pump for circulating the coolant and to the air cooling fin group; and

an electric control circuit driving the liquid cooling pump and the air cooling fan,

wherein, an input to the electric control circuit is DC current.

32 A cooling apparatus according to claim 31, wherein the electric control circuit inputs information about a temperature of the heat generator, and the liquid cooling pump and the air cooling fan are driven so as to maintain at maximum temperature within an upper limit of the heat generator.

33 An electronic device mounting a cooling apparatus according to any one of claims 1 to 32

34 (Added) A cooling apparatus according to claim 3, wherein the air cooling fin group and the base are formed in a unit.